高等学校教材

测控技术与仪器专业英语

大学英语专业阅读教材编委会组织编写

北京化工大学 韩建国
四川大学 廖俊必
主编

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前　　言

自1997年起至今，全国大部分工科院校已按教育部制定的专业调整方案陆续开设了“测控技术与仪器”专业，并正式纳入教学常规。此学科覆盖了以往的电子、测量、计量、精密仪器等近十个专业，在全国构成了数以十万计的师生队伍。本教材正是适应了这样的教学、科研形势要求，遵照“全国部分高校化工类专业英语阅读教材编委会”1999年、2000年两届会议的精神及编写要求编写而成。全书具有以下特色。

1. 从课文、词汇、阅读材料三个方面合理地覆盖测控技术与仪器领域的基本理论和主要技术的内容和信息；

2. 引用国际上较高水平的理论、思想和观点；

3. 采用具有较深厚的教学与学术背景的资料来源；

4. 词汇水平保持在四级以上。

内容与结构　全书共分为四章、十八个单元。第一章综合地介绍了测量技术的背景、基本理论、基本概念及全貌；第二章介绍了控制技术的背景、基本理论、基本概念及全貌；第三章较具体地介绍测试技术的具体内容；第四章重点介绍了当前国内外的一些新的测量技术及方法。

每篇课文之后设置了词汇表、注释、练习和阅读材料；每篇阅读材料之后也设有词汇表和注释。全书后设有总词汇表，并附有文献查阅指导、产品与技术说明书阅读指导及专业论文书写指导。

适用范围　可供电子、信息、测量、计量、自控专业的大本、大专或硕士研究生作为阅读教材用，也可供相关领域的教师、科技人员作参考教材用。

本书由北京化工大学韩建国与四川大学廖俊必主编。北京化工大学信息学院张杰老师和四川大学成都分校机械制造学院测控系张涛老师参加了本教材的部分内容编写及全书的审核、整编工作。

清华大学肖德云教授担任了本书的主审工作，并提出了一系列指导性意见，在此表示深切的谢意。

本教材的出版得到了北京化工大学化新教材建设基金的资助。

由于作者水平有限，书中难免会有疏漏，希望得到广大读者的批评指正。

编者

2002年3月

内 容 提 要

本书精选国外优秀的教材、论文，从测控技术与仪器专业培养目标出发，对测量基本原理、概念，控制系统的建模、传递函数、通信网络、现场总线等工业控制系统以及测量测试仪器与设备都进行了介绍。旨在扩大学生的知识面，培养学生专业英语的阅读能力，提高学生的词汇量。本书内容选材较新，覆盖面广，结构体系完整，配有注释、练习及专业词汇。

本书为高校测控技术与仪器专业学生的教材，亦可供相关技术人员参考。

全国部分高校化工类及相关专业
大学英语专业阅读教材编审委员会

CONTENTS

CHAPTER. 1 Introduction to Measurement

Unit 1 Definition of Measurement and Measurement Theory

Before reading the text below, try to answer the following questions:

1. What is necessary but not sufficient definition, and how to give a necessary and sufficient definition to measurement?
2. What is a satisfying definition and under what condition can a definition of measurement be considered as a satisfying one?
3. What a concept is the measurement established based on?
4. What a point on measurement results is set up in this theory?
5. What is the theoretically restricted definition of measurement?
6. What is an empirical relational system?

1. Definition of Measurement

A possible operational description of the term measurement which agrees with our intuition is the following: "measurement is the acquisition of information"; the aspect of gathering information is one of the most essential aspects of measurement; measurements are conducted to learn about the object of measurement; the measurand. This means that a measurement must be descriptive with regard to that state or that phenomenon in the world around us which we are measuring. There must be a relationship between this state or phenomenon and the measurement result. Although the aspect of acquiring information is elementary, it is merely a necessary and not a sufficient aspect of measurement: when one reads a textbook, one gathers information, but one does not perform a measurement.

A second aspect of measurement is that it must be selective. It may only provide information about what we wish to measure (the measurand) and not about any other of the many states or phenomena around us. This aspect too is a necessary but not sufficient aspect of measurement. Admiring a painting inside an otherwise empty room will provide information about only the painting, but does not constitute a measurement.

A third and necessary aspect of measurement is that it must be objective. The outcome of the measurement must be independent of an arbitrary observer. Each observer must extract the same information from the measurement and must come to the same conclusion. This, however, is almost impossible for an observer who uses only his/her senses. Observations made with our senses are highly subjective. Our sense of temperature, for example, depends strongly on any sensation of hot or cold preceding the measurement. This is demonstrated by trying to determine the temperature of a jug of water by hand. If the hand is first dipped in cold water, the water in the jug will feel relatively warm, whereas if the hand is first dipped in warm water, the water in the jug will feel relatively cold. Besides the subjectivity of our observation, we human observers are also handicapped by the fact that there are many states or phenomena in the real world around us which we cannot observe at all (e. g. magnetic fields), or only poorly (e. g. extremely low temperatures or high-speed movement) . In order to guarantee the objectivity of a measurement we must therefore use artefacts (tools or instruments) . The task of these instruments is to convert the state or phenomenon under observation into a different state or phenomenon that cannot be misinterpreted by an observer. In other words, the instrument converts the initial observation into a representation that all observers can observe and will agree on. For the measurement instrument's output, therefore, objectively observable output such as numbers on an alpha-numerical display should be used rather than subjective assessment of such things as colour, etc.. Designing such instruments, which are referred to as measurement systems, is the field of (measurement) instrumentation.

In the following, we will define measurement as the acquisition of information in the form of measurement results, concerning characteristics, states or phenomena (the measurand) of the world that surrounds us, observed with the aid of measurement systems (instruments) . The measurement system in this context must guarantee the required descriptiveness, the selectivity and the objectivity of the measurement. We can distinguish two types of information: information on the state, structure or nature of a certain characteristic, so-called structural information, and information on the magnitude, amplitude or intensity of a certain characteristic, so-called metric information. The acquisition of structural information is called a qualitative measurement, the acquisition of metric information is called a quantitative measurement. If the nature of the characteristic to be measured is not (yet) known, it must be determined first by means of a qualitative measurement. This can then be followed by a quantitative measurement of the magnitude of the respective characteristic.

2. Measurement Theory

In the previous section we have seen that measurements form the essential link between the empirical world and our theoretical, abstract image of the world. This concept forms the basis of a theory of measurement. In this theory a measurement result is considered to be a representation of the actual empirical quantity. Measurement theory treats measurements as a mapping of elements of a source set belonging to the empirical domain space (see Fig. 1. 1) onto the elements of an image (or outcome) set which is part of the abstract range (or image) space①. The quantity to be measured (the measurand) is an element of the source set. For instance, in the electrical domain we measure electrical current (source set) but only within a certain range of magnitude (elements) . The result of the measurement process② is abstract; it forms an element of the image set in the abstract range space. For example, the magnitude of the electrical current to be measured in the above example is (by measurement) assigned a certain number (element) out of the set of real numbers (image set). In other words, the elements of the source set are empirical characteristics of states and phenomena of the world around us; the elements of the image set are symbols of the abstract image set of symbols. The symbols can be numbers (quantitative measurements) but can also be, for example, names (quantitative measurements).

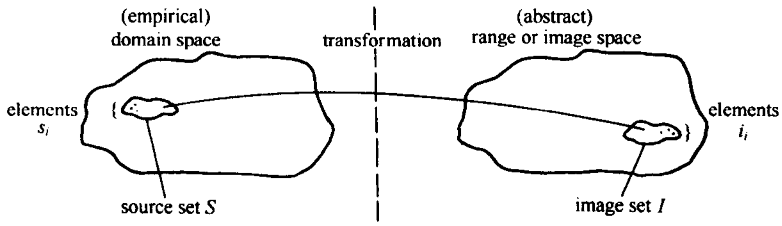

Fig. 1. 1 Measurement constitutes the mapping between an empirical domain and a range space

Restricting the definition of measurement further, measurement theory states that measurement is the mapping of elements from an empirical source set onto elements of an abstract image set according to a particular transformation function. The transformation function consists of the assignment algorithms, rules or procedures that define the representation of empirical quantities by abstract symbols. In practice the assignment algorithm, rule or procedure is implemented by the employed measurement system. The measurement system therefore determines the representation. As stated earlier, this representation must be done in a descriptive, objective and selective way. Thus, the image set must consist of elements (measurement outcomes) which are abstract symbols with a unique meaning about which, by definition, all observers agree.

A measurement must be descriptive. In measurement theory this is described in terms of set theory: the relations that exist between the elements of the source set must be maintained under the transformation in the image set, for example, 'larger than', 'equal to' and 'smaller than'. The set of relations between the elements of the source set is referred to as the relational system (of the source set).

This empirical relational system determines the structure of the source set. Likewise, an abstract relational system determines the structure of the image set (for instance, the set of relations that apply to the set of integer numbers). A measurement (representation) is now called descriptive if the relational system or structure of the empirical source set is invariant under the transformation (measurement). The measurement only represents that which is measured if the two relational systems are identical; otherwise information is lost in the mapping. An example is measuring with a very low resolution; two different current magnitudes are mapped onto the same outcome, and are indistinguishable from each other.

Selected from "Electronic measurement and instrument, by Klassen, Klass B., Cambridge University Press, 1996".

Words and Expressions

1. operational description 操作描述
2. acquisition of information 信息采集
3. object of measurement 测量目标
4. measurand n. 被测物理量 [性质，状态]，被测对象
5. measurement result 测量结果
6. a necessary and not a sufficient aspect 一个必要而非充分的条件
7. selectivity [ˌsilek'tivəti] n. 选择性
8. objective [əb'dʒektiv] adj. 客观的
9. observer [əb'zəːvə] n. 观察者；观察器
10. extract ['ekstrækt] vt. 吸取，摘取
11. arbitrary ['ɑːbitrəri] adj. 专横的，专断的，反复无常的
12. conclusion [kən'kluːʒ(ə)n] n. 结论
13. highly subjective 高度主观的
14. handicapped ['hændikæpt] adj. 残疾的
15. magnetic fields 磁场
16. objectivity [ˌɔbdʒek'tivəti] n. 客观性
17. artefact ['ɑːtifækt] n. 人工品
18. misinterpret [misin'təːprit] vt. 曲解
19. measurement instrument's output 测量装置的输出
20. structural information 结构信息
21. metric information 公制信息
22. qualitative measurement 质量测量
23. quantitative measurement 数量测量
24. nature ['neitʃə(r)] n. 本性，本质
25. respective characteristic 各自的特性
26. empirical world 经验的世界
27. abstract image 抽象的映像
28. actual empirical quantity 实际经验的数量
29. mapping of elements 元素的映射
30. source set 源集
31. empirical domain space 经验域空间
32. image set 映像集
33. abstract range space 抽象域空间
34. electrical domain 电气域
35. measurement process 测量过程
36. symbol ['simb(ə)l] n. 符号，记号，象征
37. transformation function 转换功能
38. assignment algorithm 分配算法

39. abstract symbol 抽象符号
40. employed measurement system 被使用的测量系统
41. descriptive [di'skriptiv] adj. 描述的，叙述的
42. set theory 集合论
43. relational system 相关系统

Exercises

1. Complete the summary of the text, using no more than 3 words for each answer.

   The definition for measurement such as 'measurement is the acquisition of information' and 'it must be selective' is ________, because when one gathers information, he ________ a measurement. The definition of measurement such as 'it must be selective' is ________ because when one obtains a selected information, he ________ a measurement. A satisfying definition must be ________. The third and necessary aspect of measurement is that it ________. The results of the measurement must be ________. Each observer must fetch the same information ________ and must be led to ________. This is almost impossible, because an observer may use only ________.

   From the previous section an important concept is developed that measurements sets up the essential link between ________ and ________ graphic comprehension of the world. Based on this concepts the ________ of measurement is developed. In this theory a measurement result is a ________ of the actual empirical quantity, and a measurement is treat as ________, which attributes to the ________. The measurand is an element of the ________. The result of the measurement process is abstract; it forms an element in ______. According to the theoretical definition, measurement is a ______ from ______ onto ______ of ______ according to a ______, which consists of ________. The measurement system is ________, which must be done in a ________, ________ and ______ way. The image set must consists of ________ which are ________ with a unique meaning.

2. Describe why the condition listed for the third definition of measurementmentioned in the text is impossible to be realized?
3. Illustrate the satisfying definition for measurement in your own words and using your own examples.
4. Describe what a role the qualitative measurement plays.
5. Illustrate the theoretically restricted definition of measurement.

Notes

① "Measurement theory treats…of the abstract range (or image) space. "：全句可译为：测量理论把测量理解为属于经验域空间的源集的元素到作为一个抽象范围（或称影像）空间的一部分的影像集元素的映射。句中"映射源"是"elements of a source set belonging to the empirical domain space", 映像是 "elements of an image (or outcome) set which is part of the abstract range (or image) space"

② process：这个词在下文中常常出现。当它作为名词出现时，常常指"过程"，与"系统"相近，但强调了动态特性；当它作为动词出现时，常常指"处理"，如，对信号进行处理，等等。

Reading Material 1

Descriptions of Measurement

1. Why measuring?

Why is there so much measuring going on? Apparently to provide information about the world that surrounds us, the observers. One reason may therefore be that we wish to add to and to improve our perception of that world. Abstractly speaking, our aim is to increase our knowledge of the surrounding world and the relationships that exist between characteristics, states and phenomena in this world. This is the case even when we measure such day to day quantities as tire pressure, body temperature (fever), etc. The gathered information enables us to reduce seemingly complex characteristics, states, phenomena and relationships to simpler laws and relations. Thus, we can form a better, more coherent and objective picture of the world, based on the information measurement provides. In other words, the information allows us to create models of (parts of) the world and formulate laws and theorems. We must then determine (again by measuring) whether these models, hypotheses, theorems and laws are a valid representation of the world. This is done by performing tests (measurements) to compare the theory with reality. We have actually described the application of measurement in the 'pure' sciences. We assume that 'pure' science has the sole purpose of

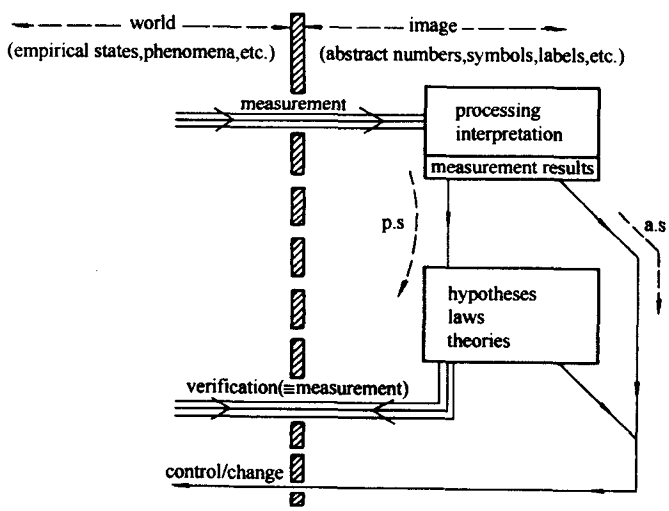

Fig. 1. 2 Measurement as the link between the real world on the one hand and its concept in the 'pure' sciences (p. s) and 'applied' science (a. s) on the other

describing the world around us and is therefore responsible for our perception of the world. Fig. 1.2 illustrates this schematically.

In Fig. 1.2 the role of measurements in 'applied' sciences is also indicated We consider 'applied' science as science intended to change the world. Thereto, it will use the models, laws and theorems of 'pure' science to modify the world around us. In this context, the purpose of measurement to regulate, controller alter the surrounding world, directly or indirectly based on the results of measurements and (existing) models, laws and theorems.

2. A Formal Description of Measurement

Let us now try to put this more formally: Assume that an empirical source set S consists of n elements s_i, so that $S=\{s_1, s_2, \cdots, s_n\}$. Let there exist k empirical relation R_j between the elements $s_i \in S$, so $R_j \subset E^{mj}$. Further, let the abstract image set I consist of m elements i_i, $I=\{i_1, i_2, \cdots, i_m\}$. Between these elements there are l relations N_j, so that $N_j \subset I^{mj}$. Clearly, if $k \neq l$, for instance, if l is large than k, the measurement outcome will suggest more information than is actually present in the measurand. Similarly, if the number of elements of the two sets is not equal($m \neq n$), for instance, $n > m$, the resolution of the mapping process may be inadequate. Therefore, for simplicity, let us assume $k=l$ and $m=n$. Now, let there be a function f that maps the elements of S onto I. We have to assume that this function is a single-valued, monotonic function in s_i. This will ensure a unique mapping onto I. The two relational systems $(S, R_1, R_2, \cdots, R_k)$ and $(l, N_1, N_2, \cdots, N_L)$ are isomorphic if:

$$\{s_1, s_2 \cdots s_{nj}\} \in R_j \Leftrightarrow \{f(s_1), f(s_2), \cdots, f(s_{nj})\} \in N_j$$

Again, the function f is implemented by the employed measurement system in the form of an algorithm, rule or procedure.

If we require isomorphism, we ensure that the relations between the elements of S are preserved; the structure remains the same. In other words, the information contained in the relations is not lost during the measurement. Although the requirement for isomorphism may preserve the structure of S, it does not define the representation entirely. It allows a certain amount of freedom in choosing the measurement procedure. This freedom can be demonstrated by transforming the measurement results using 'legal' transformations into new results which contain the same information. The requirement for isomorphism does not yield a single, unique representation, but rather a group of congruent representations. The results obtained with each of these representations can be transformed into one another, without loss of information. Such allowed transformations do not affect the structure of the empirical domain S. The information contained in the measurement results is invariant with respect to the allowed transformations. The allowed transformations therefore show exactly how unique the assignment of measurement values is.

Selected from "Electronic measurement and instrument, by Klassen, Klass B., Cambridge University Press, 1996".

Words and Expressions

1. gathered information 收集到的信息

2. enable [i'neib(ə)l] vt. 使……有能力
3. theorem ['θiəram] n. 定理；法则
4. valid representation 有确凿根据的陈述
5. hypothesis [hai'pɔθisis] n. 假说，假设，学说； pl. hypotheses
6. schematically [ski'mætikəli] 概要地
7. simplicity [sim'plisiti] n. 简单地
8. single-value 单值
9. monotonic function 单调函数
10. measurement constitute 测量组成
11. isomorphic [aisəu'mɔːfik] adj. 同形的，[数] 同构的
12. preserve [pri'zɛːv] vt. 保护，保存
13. legal transformation 合法转换
14. yield [jiːld] v. 出产，生长，生产
15. congruent representation 适合的表述法
16. monotonic [ˌmɔnə'tɔnik] adj. 单调的；没有变化的
17. invariant [in'veəriənt] adj. 无变化的，不变的； n. [数] 不变式，不变量

Unit 2　Measurement of Quantities and Measurement Data

Before reading the following text, try to answer the questions:

1. What physical quantities are often used in test and measure technology?
2. What energy system do physical quantities attribute to?
3. How do people make standards for these physical quantities?
4. What important usages are there for the quantities?
5. What do people mean with the term 'data'?
6. What are qualitative data and quantitative data?
7. How do people categorize numerical data?
8. What stages will the data go through after it is collected?

1. Measurement of Physical Quantity

The physical quantities listed bellow are often used in test and measure technology. The first 2 are commonly called as electrical quantities and the other are commonly called as electrical parameters.

Usually the sensors receive the information of quantities under measurement (QUM) and convert it into variation of electrical parameters or electrical potential, which will normally be conditioned, and then converted into the electrical quantities, specially the current, and sent to the A/D converters.

Electrical potential difference

The primary standard for electrical potential difference used to be provided by an electrochemical standard cell (the Weston standard cell). The voltage of a Weston cell is approximately 1.01860 V at 20℃, with an inaccuracy of 3×10^{-6} under optimal conditions. Optimal conditions mean a variation of temperature less than 10^{-3} K, no load, no vibrations or jolting. The cell must remain in an upright position. A Weston standard cell has a very long thermal after-effect. After the cell has been heated to 30℃ it can take 6 months before it is totally stable within 0.3 μV of the original value at 20 degrees. Furthermore, a Weston cell will age, resulting in an increase in the internal resistance ($R_I\approx 500\sim1000\Omega$), and a small decrease of a few μV in the output voltage (during the first years).

Electrical current

Electrical current is standardized by measurement with an instrument called a 'current balance'. This device measures the electromagnetic force between two current carrying coils (one fixed, one moving) by balancing it with the force of gravity, acting on a known mass. The force between the coils is given by $F = I^2\mathrm{d}M/\mathrm{d}x$, in which M is the known mutual induction of the coils and x is the known distance between them. The differential quotient $\mathrm{d}M/\mathrm{d}x$ is determined by the known geometry of the coils.